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FORECASTS FOR THE 1990 STIKINE RIVER SOCKEYE SALMON RUN

By Kathleen Jensen

Regional Information Report No. 1J90-16 —— August 1990

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Alaska Department of Fish and Game
Division of Commercial Fisheries
Juneau, Alaska

August 1990

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ACKNOWLEDGEMENTS

I gratefully acknowledge the efforts of many people who contributed to the data base on which this report is based. I am grateful to personnel of the Port Sampling Project of the Division of Commercial Fisheries, Southeast Region, Alaska Department of Fish and Game and to personnel of the Canadian Department of Fisheries and Oceans for their assistance in gathering samples from catches and escapements. I also wish to acknowledge the efforts of personnel of the Division of Commercial Fisheries who aged and digitized sockeye salmon scales during the years 1983 through 1989. In particular, I wish to thank Scott McPherson and Andy McGregor for providing age compositions for the catches and escapements for the Stikine River and for Southeast Alaska, Scott McPherson and Sue McGregor for providing stock compositions for Stikine River catches, and Glen Oliver for providing stock compositions for District 106 catches.

PROJECT SPONSORSHIP

This investigation was partially financed with Anadromous Fish Conservation Act (P.L. 89-304 as amended) funds under Contract No. NA89AA-D-FM110, and with U.S./Canada Pacific Salmon Treaty funds, under Cooperative Agreement NA90AA-H-FM010.

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ABSTRACT

Preseason forecasts of the Tahltan, non-Tahltan and the entire Stikine River sockeye salmon runs for 1990 were made based on spawner-recruit and sibling analyses and on smolt analysis for the Tahltan stock. Spawner-recruit forecasts for the Tahltan, non-Tahltan, and Stikine runs were 7,461 (R_2=.38), 53,751 (R_2=.39), and 54,544 (R_2=.33) fish, respectively. The spawner-recruit analyses were not used due to the high variance. With only three data points there was a large uncertainty around the smolt forecast of 39,531 Tahltan fish which also precluded its use as a forecast technique. Sibling analysis was chosen as the Alaska Department of Fish and Game forecasting method. Linear regressions of the number of age-1.2 fish in year *t* versus the entire run in year *t*+1 were made based on six brood years of age-specific catch and escapement data. The 1990 run predictions for the Tahltan, non-Tahltan, and Stikine (Tahltan + non-Tahltan) groups were 27,523 (R^2=.91), 20,236 (R^2=.82), and 51,889 (R^2=.97) sockeye salmon, respectively. Due to the limited number of data points, these sibling forecasts are considered experimental and should not be viewed as a proven technique for forecasting the run sizes of these stocks.

INTRODUCTION

A preseason forecast of the Stikine River sockeye salmon (*Oncorhynchus nerka*) run is needed each year to determine early season fisheries management procedures for Alaska gill net fisheries near the Stikine River and for the Canadian inriver gill net fisheries, as stipulated by the U.S./Canada Pacific Salmon Treaty. This paper presents the forecast method developed by the Alaska Department of Fish and Game (ADF&G) for 1990. The forecast used jointly by the two countries has been an average of the ADF&G and the Canadian Department of Fisheries and Oceans (CDFO) forecasts.

Sockeye salmon (*Oncorhynchus nerka*) of transboundary Stikine River origin are harvested in U.S. marine fisheries in Southeast Alaska's Districts 106 and 108 and in Canadian fisheries in the Stikine River (Figure 1). Management of transboundary river salmon to achieve conservation and allocation objectives, as stipulated by the Pacific Salmon Treaty, requires a cooperative approach by Canada and the United States. In order to facilitate cooperative management of Stikine River sockeye salmon, the Transboundary Technical Committee developed a management model based on preseason and in-season forecasting, catch-per-unit-effort (CPUE) data, desired escapement goals, and total allowable catch (TAC). This model was used in 1988 and 1989 and will be used in 1990 (TTC 1988; TTC 1989; TTC 1990). The TAC output from the model is based on the preseason forecast for the first two weeks of the season and on in-season CPUE in various fisheries for the remainder of the season. There is limited data available on which to base preseason forecasts. Various methods, with varying degrees of success, have been used the past few years. Improved accuracy of the preseason forecast would be valuable to fishery managers, particularly during the early portion of the run when little other data is available to assess run strength. Two major stock groups are recognized for the Stikine River sockeye run: 1) the Tahltan group which spawns in Tahltan Lake; and 2) the non-Tahltan group which spawns in small lakes, sloughs, and side channels of the mainstem river and its tributaries. Most Stikine River sockeye salmon mature as age-1.3 fish. Other important age groups include ages -1.2, -2.2, -2.3, -0.2, and -0.3, with the latter two groups found only in the non-Tahltan stock group.

Preseason salmon forecasts have been an integral part of fisheries management on the west coast for decades. Several methods have met with varying degrees of success. Spawner-recruit analysis, although primarily a method of estimating optimum escapement levels, has been used to forecast sockeye salmon runs. In Alaska it is used to forecast the Copper River sockeye run (Geiger and Savikko 1990). The forecast for the Bristol Bay sockeye run is based on the mean or weighted (by variance) mean of linear regressions of spawner-recruit, sibling, smolt, and Japanese research vessel catches (Fried and Yuen 1987). Sibling forecasting, using the return of age n fish in year t to predict the return of age n+1 fish in year t+1, has been used as a sole technique and in conjunction with other forecasting methods. A simple linear regression has been used for the major age groups for Coghill Lake sockeye salmon, while multiple regressions incorporating numbers of spawners, numbers of smolt, and/or length data have been used for sockeye returns to Kodiak Island and Chignik (Geiger and Savikko 1990). Sibling forecasting has worked very well for coho salmon runs in Oregon where a simple linear regression of the number of jacks in year t has been used to predict the run in year $t+1$ (Gunsolus 1978; GAO 1983). Bilton (1973) found that although there were positive correlations between the catch or run of 3-year-old chum salmon in year t and the catch or run of 4-year-old chum salmon in year $t+1$, sibling forecasting was not feasible due to the high variation. Sibling forecasting of sockeye salmon runs in Alaska has met with varying degrees of success.

The purpose of this study was to determine if sibling, spawner/recruit, or smolt data could be used to predict the Tahltan, non-Tahltan, or entire Stikine River sockeye run.

METHODS

Database

I compiled the catch and escapement data for the Tahltan and non-Tahltan stock groups and for the entire Stikine (Tahltan + non-Tahltan) sockeye run from 1983 through 1989 (Appendix A). Inriver run size estimates for Tahltan and non-Tahltan fish are available since 1979; however, stock compositions of marine catches were not estimated prior to 1982 and in that year the Tahltan and non-Tahltan groups were not separated. Therefore, the reliable data base for age- and stock-specific catch and escapement includes 1983 and later.

Age compositions were compiled from yearly catch and escapement reports produced by the Alaska Department of Fish and Game and included the years: 1983 (McGregor et al. 1984), 1984 (McGregor and McPherson 1986), 1985 (McPherson and McGregor 1986), 1986 (McPherson et al. 1988), 1987 (McPherson et al. 1988), 1988 (McPherson et al. in prep.), and 1989 (McPherson et al. in prep.). Stock compositions for catches were compiled from various published and unpublished ADF&G reports and memorandums. Stock compositions for District 106 catches were compiled for the years: 1983 (Oliver et al. 1984), 1984 (Oliver and Walls 1985), 1985 (Oliver and Jensen 1986), 1986 (Jensen et al. 1989), 1987 (Jensen and Frank 1988), 1988 (Jensen and Frank 1989), and 1989 (Jensen and Lynch *in prep.*). Stock compositions for District 108 catches were compiled for the years: 1985 (Jensen 1986) and 1986 through 1989 (references as listed for District 106). Stock compositions for the inriver Stikine catches were compiled for the years: 1983 (Walls 1984a), 1984 (Walls 1984b), 1985 (ADF&G data file), 1986

(Jensen et al. 1989), 1987 (TTC 1988), 1988 (TTC 1990), and 1989 (TTC *in prep*). Catches for each fishery and the Tahltan and non-Tahltan escapement estimates for 1983 through 1989 were taken from the most current source (TTC *in prep*) and, in most cases, have been updated since those listed in the original reports.

Scale collections from Tahltan Weir escapements used to estimate the age compositions in the above reports were provided by the CDFO; the scales from inriver catches and from non-Tahltan escapements were collected by CDFO and ADF&G personnel; and scales used for age and stock composition estimates for District 106 and 108 catches were collected by ADF&G personnel.

Not all catches were analyzed in all years and some assumptions about stock and age compositions were made. It was assumed that 90% of the Canadian commercial and Indian food fishery catches in the upper Stikine River were comprised of Tahltan fish and 10% were comprised of non-Tahltan fish (based on an unpublished analysis of a limited database of scale circuli counts). The age composition of the Tahltan stock in the upper river catches was assumed to be the same as that of the escapement through Tahltan Weir in all years. The age composition of the non-Tahltan stock in the upper river catches was assumed to be the same as that of the lower river test fishery catch when that data was available (1985-1989), of the lower river commercial catch in 1983, and of the Tahltan escapement in 1984 (no other data available). Fish captured in the Kakwan Point test fisheries and the sonar test fisheries below the U.S./Canada border were accounted for elsewhere as they were released alive and, therefore, were not included in the total catch calculations. The average age and stock compositions of District 108 commercial and test fishery catches from 1985 through 1989 were used for 1983 and 1984. The age and stock compositions for the District 108 test fishery catch in 1985 were used for the commercial catch in 1985. The age and stock compositions for the District 108 commercial catches in 1987 and 1989 were used for the test fishery catches in those years. The District 106 commercial catch stock and age compositions in 1984, 1985, 1987, and 1989 were used to represent the stock and age compositions of the District 106 test fishery catches for those years.

Spawner-Recruit Analysis

The potential for spawner-recruit analysis was investigated for each of the stock groups, Tahltan and non-Tahltan, and for the entire Stikine River sockeye run. Forecasts were based on a linear form of the Ricker curve (1954), and a form modified for age-specific returns (Brannian et al. 1982).

$$R/S = a + e^{-(bS)}$$

$$\ln(R_{it}/S_t) = \ln(a) - bS_t$$

where:

R_{it} = number of recruits age i from spawning during brood year t,
S_t = number of spawners in year t.

The database was sufficient to analyze only six brood years, beginning with the 1979 parent year and ending with the 1984 parent year. The recruits from the 1984 spawning were incomplete as the age-2.3 fish will not return until 1990. The same years were used for the age-specific spawner recruit regressions, except that the years 1978-1983 were used for age-2.3 fish.

Smolt-Recruit Analysis

Due to the limited data base (1984-1986) for smolt outmigrations from Tahltan Lake, a smolt-recruit regression analysis could not be accomplished for the Tahltan stock. An average percent survival forecast was made by multiplying the number of smolt by the average survival rate and assuming an average marine age composition for the returns. There is no information on smolt outmigrations for the non-Tahltan stock group.

Sibling Analysis

Linear regressions were tried for five relationships: age-1.2 versus -1.3; age-1.2 versus all age groups; age-1.2 versus all ages other than age-0.; age-0.2 versus age-0.; and age-1.2 + age-0.2 versus all returning fish. Some of the data sets were not standard sibling relationships where the return of age n fish in year t is used to predict the return of age n+1 fish in year t+1. The last three regressions were not used for the Tahltan group as age-0. fish are not present in that stock. Forecasts for the 1990 run were made for each group using data from all years (1983-1989). The accuracies of the regressions were tested by cross-validation with a "leaving-one-out" approach. The absolute error and error as a percent of actual run were estimated for each regression and group by calculating the absolute difference between the actual and predicted run size for every year (1983-1989). Errors were compared among regressions for each stock group and between stock groups.

RESULTS

Spawner-Recruit Analysis

Brood tables (Appendix A.4) from each of the stock groups indicated little correlation between spawning escapement and adult return (Figure 2). The smallest escapements of the Tahltan stock, 10,211 and 11,081 fish, produced 28,664 and 122,870 fish, respectively. A non-Tahltan escapement of 30,806 produced a return of 96,508 fish, while an escapement of 29,307 fish produced a return of 35,393 fish. Stikine River escapements of 41,824 and 48,221 fish produced returns of 219,378 and 44,371 fish, respectively. The regressions for all ages combined for the Tahltan, non-Tahltan, and Stikine River groups had R^2s of .38, .39, and .33, respectively, and predicted returns of 7,461, 53,751, and 54,554 fish, respectively, from the 1985 brood year. The age-specific regressions generally had low correlations and had R^2s ranging from 0 to .84 (Table 1). The predicted 1990 runs of the Tahltan, non-Tahltan, and Stikine River groups were 9,971, 50,205, and 57,297, respectively.

Smolt-Recruit Analysis

The three data points available for the Tahltan smolt-recruit were insufficient to detect any trend (Figure 2)(Appendix A.5). The 1984 and 1986 outmigrations of 219,702 and 244,330 smolt had survival rates of 6.4% and produced returns of 14,073 and 15,516 adults, respectively, while the 1985 smolt outmigration of 613,531 fish had a survival rate of 1.2% and produced a return of 7,031 adults. The smolt forecast (assuming average survival and average marine age of return) for the 1990 Tahltan run was 39,531 fish.

Sibling Analysis

The sibling forecasts for a given stock group were generally similar regardless of which ages were used (Appendices B and C). The predicted 1990 runs (all ages) for the Tahltan, non-Tahltan, and Stikine River groups are 27,523 (R^2=.91), 20,236 (R^2=.82), and 51,889 (R^2=.97) sockeye salmon (regression 2, Table 2). Graphical analysis indicates that the Tahltan regressions are strongly driven by a single data point (X in 1984 and Y in 1985)(Figure 3). The linearity of the data without the 1984/1985 value is greatly reduced. The non-Tahltan regressions are also highly influenced by a single data point (X in 1984, Y in 1985) (Figure 3) but retain a moderate linearity even without the point of greatest influence. A strong linear relationship occurred between Stikine River age-1.2 fish in year t and age-1.3 fish in year t+1 and a slightly less strong relationship existed for other regressions (Appendix C.2.). Even without the point of greatest influence, there was a linear trend between the age-1.2 fish in one year and the entire run the following year (Figure 5).

The average percent forecast error for total run, estimated by cross-validation with a leaving-one-out approach, was lowest for regression 2 for all groups. The average error rate for the Tahltan group was 50.2% (Table 3), for the non-Tahltan group 28.2% (Table 4), and for the Stikine group 13.4% (Table 5).

DISCUSSION

There appears to be little correlation between the number of spawners and the number of recruits for the Stikine River sockeye salmon run as a whole, or for either of the component stock groups. The three years of smolt data for the Tahltan stock are insufficient to show any smolt-recruit correlations. It is possible that a spawner-recruit correlation exists for the Tahltan and non-Tahltan stocks but is masked due to the high variability of the data and the limited number of data points. In addition, there are potential sources of error in the age-specific catch of escapement data. The catches of Tahltan and non-Tahltan fish are estimated with proven techniques and variances can be determined. However, assumptions are made for some catches when samples were unavailable, for example, the test fish catches are assumed to have the same age and stock compositions as the commercial catches in some years. The Tahltan escapement is known since it is counted at the weir, however, there is an unknown and potentially large uncertainty associated with the non-Tahltan escapement estimates. The estimate is based on the ratio of non-Tahltan to Tahltan fish int he inriver run, migratory timing (estimated from standardized test fishery CPUE data), and the Tahltan run strength. The potential errors in the non-Tahltan escapement would effect all forecasts for this stock and for the entire Stikine River sockeye run.

All aspects of this analysis are affected by the paucity of data. Due to the small number of data pairs, each has a very high weight and, thus, an abnormal year may exert unduly high influence on any correlations present. Also, with only a few years of data, it is not possible to positively ascertain which, if any of the years, are abnormal. I made a cursory sibling forecast of the Tahltan stock of Stikine River sockeye salmon in 1988, based on only four years of data. The return of age-1.2 Tahltan sockeye in 1987 was used to forecast the return of age-1.3 sockeye salmon in 1988, and the number of age-1.3 fish was expanded to the total run by the average (1983-1987) proportion of the run comprised of that age group.

The method correctly predicted a small run and I made the forecast again in 1989, based on five years of data. This forecast was incorporated into the Stikine management model and, although not as accurate as the forecast of the previous year, it correctly predicted a small run. The sibling forecast was again incorporated into the Stikine management model for 1990. The prediction for the 1990 Tahltan run (27,523 fish) seems low, particularly in light of the smolt outmigrations in 1987 and 1988 (810,432 and 1,170,136) which will be returning as 3- and 2- ocean fish, respectively. The smolt forecast indicated a 1990 run substantially larger than that estimated by the sibling forecast. In light of the small number of data points on which the forecast is based and the apparently conflicting predictions which could be made from other data, the sibling forecast for 1990 should be considered an experimental forecast and not a tried and proven method.

The cross-validation of the sibling forecast of the Tahltan run indicated a highly variable error rate (ie. lack of precision). In general, years with low runs were overestimated and years with high runs were underestimated. The error rates for the non-Tahltan forecasts were lower and less variable than for the Tahltan group. This was unexpected since the uncertainty associated with estimates of age-specific catch and escapement are larger for the non-Tahltan group than for the Tahltan stock. It had seemed likely that the potential errors in the age-specific estimates of the non-Tahltan stocks could mask trends in sibling returns and result in poor forecasts, especially with only six data pairs to analyze. The low error rates, indicated by cross-validation, of the entire Stikine run were also unexpected. Part of the low error rate may be attributed to the small variance of the combined inriver estimates (i.e., stock composition is no longer a component). The cross-validation forecast of the 1984/1985 data pair correctly predicted a large run for all regressions including that for the Tahltan group which had an R^2 of only 0.18. Since that data pair was far out of the range of the data points incorporated into the analyses, it indicates that x coefficients were not dramatically altered by the point of highest influence. It also indicates that, even though regressions with all data pairs included are strongly driven by the 1984/1985 data pair, the regressions without that point are still relatively linear for the non-Tahltan and Stikine River data sets.

Sibling forecasting appears to be a promising technique for predicting the sockeye salmon run to the Stikine River as a whole and to its components the Tahltan and non-Tahltan stock groups. More years of data are requisite to determine the reliability of the forecast, particularly years with intermediate to large runs. More data points are also required to determine what, if any, correlation exists between the number of spawners or smolts and the number of recruits.

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Table 1. Regressions for spawner-recruit forecasts of the 1990 Stikine River sockeye salmon run.

	Recruit age					
	All ages	1.2	1.3	2.2	2.3	0.3
Tahltan						
Constant	1.49385	-1.28672	1.27766	-2.94295	-1.13744	
Std Err of Y Est	1.19732	1.65282	1.28927	0.51503	0.41435	
R Squared	0.37873	0.21646	0.34525	0.61703	0.84188	
No. of Observations	6	6	6	6	6	
Degrees of Freedom	4	4	4	4	4	
X Coefficient(s)	-0.00005	-0.00005	-0.00005	-0.00004	-0.00006	
Std Err of Coef.	0.00004	0.00005	0.00004	0.00002	0.00001	
Spawners	67326	32777	67326	67326	20280	
Predicted Recruits	7461	1702	5978	268	2023	
Sum of Age Specific Predictions	9971					
Non-Tahltan						
Constant	1.09090	-0.69492	0.74170	-2.70162	-2.14767	-2.14767
Std Err of Y Est	0.39901	0.39416	0.51933	0.49208	1.59569	1.59569
R Squared	0.39310	0.54987	0.29997	0.37831	0.00000	0.00000
No. of Observations	6	6	6	6	6	6
Degrees of Freedom	4	4	4	4	4	4
X Coefficient(s)	-0.00002	-0.00002	-0.00002	-0.00002	0.00000	0.00000
Std Err of Coef.	0.00001	0.00001	0.00001	0.00001	0.00005	0.00005
Spawners	90617	38107	90617	90617	30910	30910
Predicted Recruits	53751	7577	34487	884	3629	3629
Sum of Age Specific Predictions	50205					
Stikine						
Constant	1.21970	-0.88091	0.93277	-2.64005	-1.42301	-3.31442
Std Err of Y Est	0.68998	0.68350	0.77120	0.46211	0.64655	0.59831
R Squared	0.33095	0.35582	0.29423	0.57343	0.44820	0.15109
No. of Observations	6	6	6	6	6	6
Degrees of Freedom	4	4	4	4	4	4
X Coefficient(s)	-0.00001	-0.00002	-0.00001	-0.00002	-0.00002	0.00001
Std Err of Coef.	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Spawners	157943	70884	157943	157943	51190	51190
Predicted Recruits	54554	10052	38578	907	5026	2734
Sum of Age Specific Predictions	57297					
Sum of Tahltan and Non-Tahltan						
Spawners	157943	70884	157943	157943	51190	30910
Predicted Recruits	61211	9280	40464	1152	5652	3629
Sum of Age Specific Predictions	60177					

Table 2. Regressions used in sibling forecasts of Stikine River sockeye salmon runs and forecasts for 1990.

REGRESSION

Regression	Independent Age	Dependant Year	Age	Year	non-Tahltan	Tahltan	Stikine
1	1.2	t	1.3	t+1	yes	yes	yes
2	1.2	t	all	t+1	yes	yes	yes
3	1.2	t	all non 0	t+1	no	yes	yes
4	0.2	t	all 0	t+1	no	yes	yes
5	1.2+0.2	t	all	t+1	no	yes	yes
6	results of regressions 3 + 4				no	yes	yes

FORECASTS

Regression		Tahltan	non-Tahltan	Stikine	Tahltan + non-Tahltan
Regression 1:	Age-1.3	21,056	8,717	30,302	29,773
Regression 2:	All ages	27,096	19,840	50,878	46,936
Regression 3:	All non age-0.		16,874	45,832	
Regression 4:	All age-0.		3,989	3,989	
Regression 5:	All ages		18,958	48,759	
Estimate 6:	R3+R4		20,863	49,820	
Average total run (R2, R5, E6)			19,887	49,819	

Table 3. Actual versus predicted run size for Tahltan sockeye salmon from cross-validation of sibling forecasts (1984-1989).

Year	Run Size		Absolute Error	
	Actual	Predicted	Number	Percent
Regression 1: X=age-1.2 Y=age-1.3				
1984	24,695	14,025	10,670	43.2
1985	106,164	75,360	30,804	29.0
1986	30,501	23,614	6,887	22.6
1987	11,343	6,559	4,784	42.2
1988	5,206	10,292	5,086	97.7
1989	10,572	28,703	18,132	171.5
Average			12,727	67.7
Regression 2: X=age-1.2 Y=all ages				
1984	40,768	17,856	22,913	56.2
1985	111,211	83,502	27,709	24.9
1986	33,793	30,398	3,394	10.0
1987	14,235	14,119	116	0.8
1988	9,412	17,360	7,948	84.5
1989	15,634	35,102	19,469	124.5
Average			13,592	50.2

Table 4. Actual versus predicted run size for non-Tahltan Stikine sockeye salmon from cross-validation of sibling forecasts (1984-1989).

Year	Run Size Actual	Run Size Predicted	Error Number	Error Percent
Regression 1: X=age-1.2 Y=age-1.3				
1984	23,044	31,991	8,948	38.8
1985	76,500	75,774	726	0.9
1986	31,449	38,592	7,144	22.7
1987	21,889	32,750	10,861	49.6
1988	21,784	7,718	14,066	64.6
1989	56,214	39,398	16,816	29.9
Average			9,760	34.4
Regression 2: X=age-1.2 Y=all ages				
1984	43,932	46,621	2,690	6.1
1985	103,290	97,869	5,420	5.2
1986	41,684	57,477	15,793	37.9
1987	34,073	49,623	15,549	45.6
1988	35,745	18,714	17,030	47.6
1989	78,208	57,182	21,027	26.9
Average			12,918	28.2
Regression 3: X=age-1.2 Y=non age-0.				
1984	39,184	40,614	1,430	3.6
1985	92,393	82,538	9,855	10.7
1986	40,157	49,764	9,608	23.9
1987	29,010	43,630	14,620	50.4
1988	31,379	15,595	15,784	50.3
1989	63,905	51,340	12,566	19.7
Average			10,644	26.4
Regression 4: X=age-0.2 Y=age-0.				
1984	4,748	4,474	274	5.8
1985	10,897	7,384	3,513	32.2
1986	1,528	12,987	11,460	750.1
1987	5,063	4,967	96	1.9
1988	4,366	4,139	227	5.2
1989	14,303	5,909	8,394	58.7
Average			3,994	142.3

Table 4. (page 2 of 2.)

	Run Size		Error	
Year	Actual	Predicted	Number	Percent
Regression 5: X=age-0.2 + -1.2 Y=all ages				
1984	43,932	46,453	2,522	5.7
1985	103,290	92,539	10,751	10.4
1986	41,684	60,510	18,826	45.2
1987	34,073	47,885	13,811	40.5
1988	35,745	16,254	19,491	54.5
1989	78,208	59,198	19,011	24.3
Average			14,069	30.1
Predicted from R3+R4, Actual from R2				
1984	48,680	45,087	3,592	7.4
1985	114,187	89,921	24,265	21.3
1986	43,212	62,752	19,540	45.2
1987	39,136	48,598	9,461	24.2
1988	40,111	19,735	20,376	50.8
1989	92,511	57,249	35,262	38.1
Average			18,749	31.2

Table 5. Actual versus predicted run size for Stikine River sockeye salmon from cross-validation of sibling forecasts (1984-1989).

	Run Size		Error	
Year	Actual	Predicted	Number	Percent
Regression 1: X=age-1.2 Y=age-1.3				
1984	47,739	45,885	1,854	3.9
1985	182,664	175,109	7,555	4.1
1986	61,950	62,093	143	0.2
1987	33,232	39,443	6,210	18.7
1988	26,990	21,597	5,394	20.0
1989	66,786	67,804	1,019	1.5
Average			3,696	8.1
Regression 2: X=age-1.2 Y=all ages				
1984	84,700	64,174	20,526	24.2
1985	214,501	209,564	4,937	2.3
1986	75,477	87,275	11,798	15.6
1987	48,309	62,757	14,449	29.9
1988	45,156	42,873	2,283	5.1
1989	93,842	90,717	3,125	3.3
Average			9,520	13.4
Regression 3: X=age-1.2 Y=non age-0.				
1984	79,952	58,100	21,852	27.3
1985	203,604	187,781	15,822	7.8
1986	73,949	79,775	5,825	7.9
1987	43,245	57,185	13,940	32.2
1988	40,790	37,855	2,936	7.2
1989	79,539	85,516	5,977	7.5
Average			11,059	15.0
Regression 4: X=age-0.2 Y=age-0.				
1984	4,748	5,153	405	8.5
1985	10,897	7,384	3,513	32.2
1986	1,528	12,987	11,460	750.1
1987	5,063	4,967	96	1.9
1988	4,366	4,139	227	5.2
1989	14,303	5,909	8,394	58.7
Average			4,016	142.8

Table 5. (page 2 of 2.)

Year	Run Size		Error	
	Actual	Predicted	Number	Percent
Regression 5: X=age-0.2 + -1.2 Y=all ages				
1984	84,700	63,451	21,249	25.1
1985	214,501	195,917	18,583	8.7
1986	75,477	90,113	14,636	19.4
1987	48,309	61,317	13,008	26.9
1988	45,156	40,520	4,636	10.3
1989	93,842	93,061	781	0.8
Average			12,149	15.2
Predicted from R3+R4, Actual from R2				
1984	84,700	63,253	21,447	25.3
1985	214,501	195,165	19,335	9.0
1986	75,477	92,762	17,285	22.9
1987	48,309	62,152	13,844	28.7
1988	45,156	41,994	3,162	7.0
1989	93,842	91,426	2,416	2.6
Average			12,915	15.9

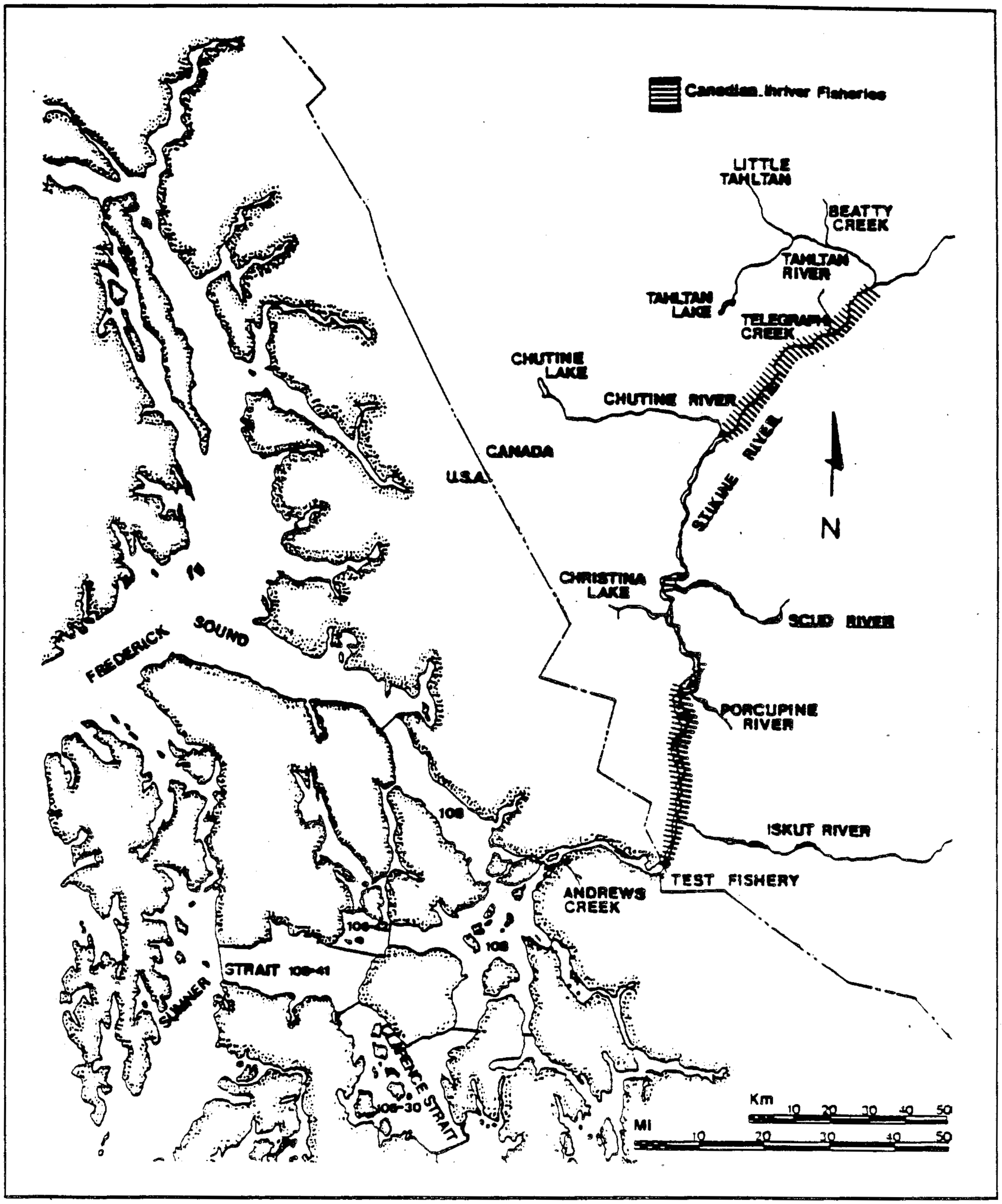

Figure 1. The transboundary Stikine River and major U.S. and Canadian fishing areas.

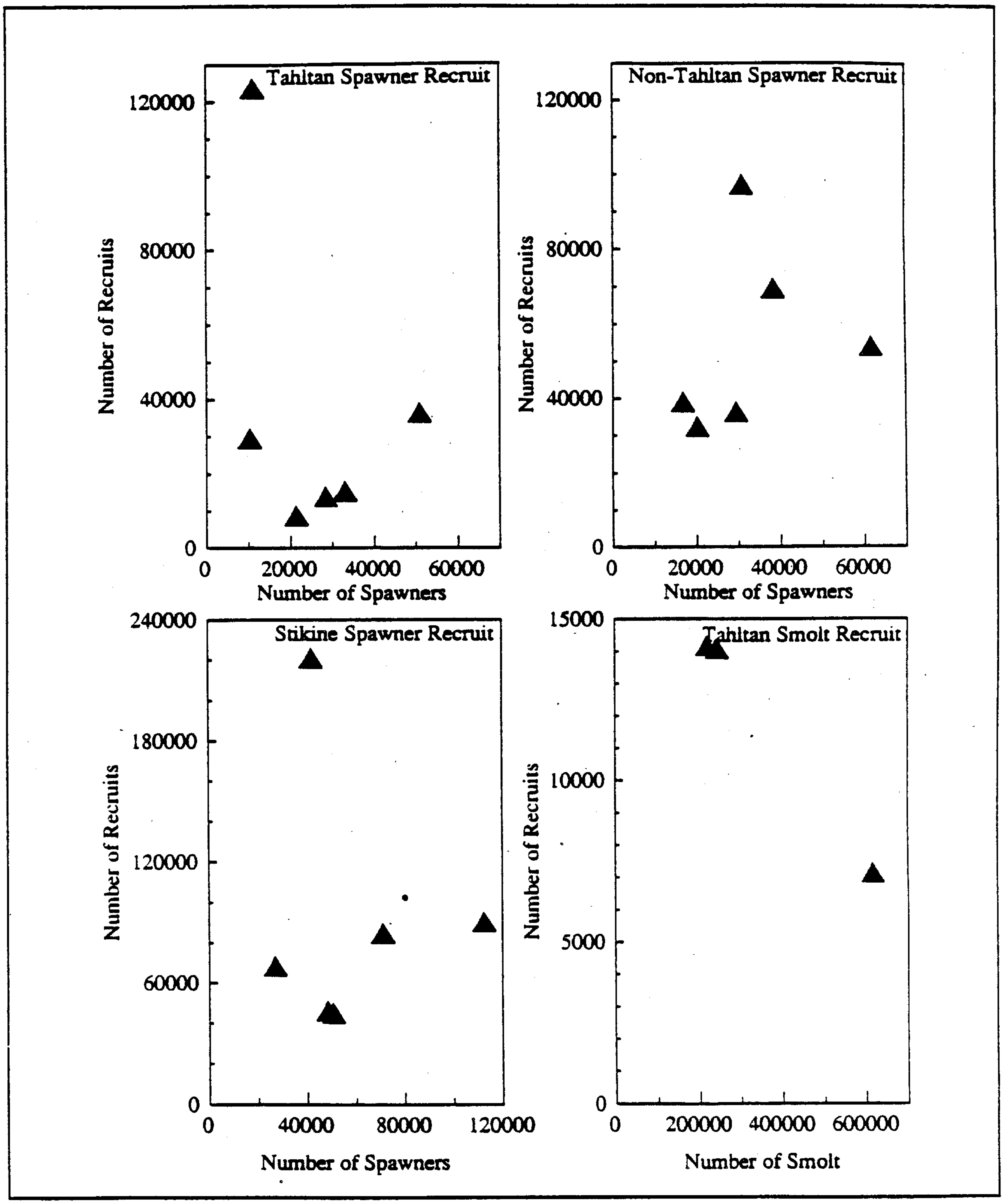

Figure 2. Spawner-recruit relationships for Tahltan, non-Tahltan, and Stikine sockeye salmon and a smolt-recruit relationship for Tahltan sockeye salmon.

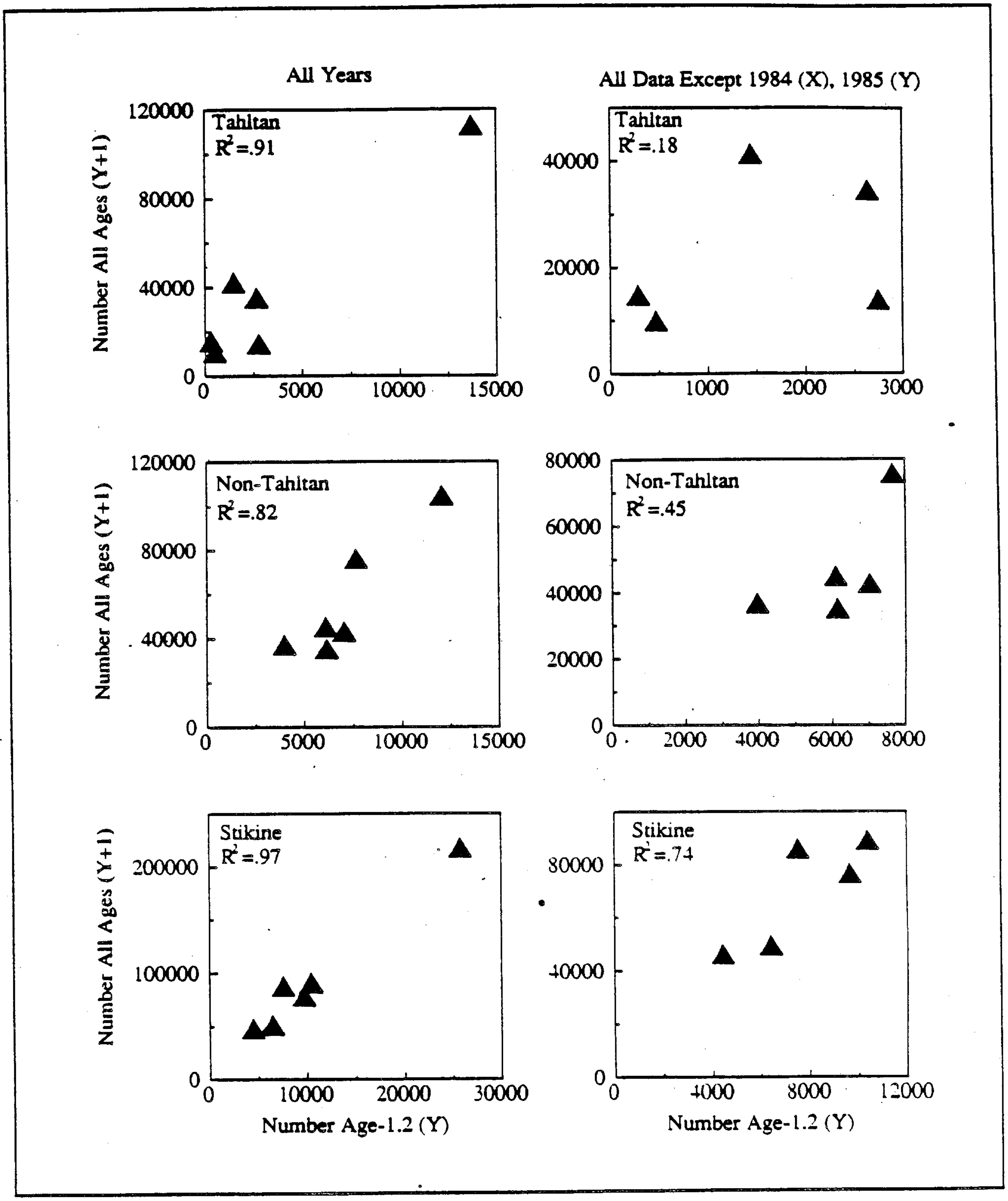

Figure 3. Correlations for age-1.2 Stikine sockeye salmon in year t and the entire run in year $t+1$. Tahltan (top), non-Tahltan (middle), and Stikine (bottom) sockeye salmon with all years of data (left) and all years except the data pair with highest influence (Y 1984, X 1985) (right).

APPENDICES

Appendix A.1. Age-specific catch and escapement of Tahltan sockeye salmon, 1983-1989.[a]

Year and Area	Age-Specific Catch and Escapement				
	1.2	1.3	2.2	2.3	Total
1983					
106	147	4,594	0	289	5,030
108	5	35	1	4	45
L.R. Commercial	720	5,364	35	573	6,692
U.R. Commercial	12	504	1	35	553
Indian Food Fish	92	3,818	6	269	4,184
Tahltan Escape.	468	19,394	29	1,365	21,256
Catch	977	14,315	42	1,169	16,504
Escapement	468	19,394	29	1,365	21,256
Totals	1,445	33,710	71	2,534	37,760
1984					
106	1,084	1,518	0	70	2,673
108	39	254	4	26	323
106-41T	16	23	0	1	40
108T	24	114	3	21	161
L.R. Commercial	0	0	0	0	0
U.R. Commercial	0	0	0	0	0
Indian Food Fish	1,598	2,908	56	233	4,794
Tahltan Escape.	10,928	19,878	381	1,590	32,777
Catch	2,762	4,817	62	350	7,991
Escapement	10,928	19,878	381	1,590	32,777
Totals	13,690	24,695	443	1,940	40,768
1985					
106-41&42	345	18,226	0	230	18,801
106-30	12	5,171	0	61	5,244
108	7	291	2	10	310
106-41T	9	460	0	6	475
108T	8	345	2	12	367
Stikine Test	23	463	5	14	505
L.R. Commercial	481	9,769	108	291	10,649
U.R. Commercial	23	931	3	19	976
Indian Food Fish	153	6,258	19	128	6,558
Tahltan Escape.	1,574	64,248	193	1,311	67,326
Catch	1,060	41,916	139	770	43,885
Escapement	1,574	64,248	193	1,311	67,326
Totals	2,634	106,164	332	2,081	111,211

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Appendix A.1. (page 2 of 3.)

	Age-Specific Catch and Escapement				
Year and Area	1.2	1.3	2.2	2.3	Total
1986					
106-41&42	0	1,740	0	330	2,070
106-30	0	0	0	11	11
108	0	393	0	0	393
106-41T	0	6	0	2	8
106-30T	0	0	0	0	0
108T	12	230	7	25	274
Stikine Test	3	151	3	10	167
L.R. Commercial	75	5,513	69	412	6,069
U.R. Commercial	6	665	7	56	734
Indian Food Fish	30	3,431	37	289	3,787
Tahltan Escape.	160	18,373	198	1,549	20,280
Catch	126	12,128	123	1,136	13,513
Escapement	160	18,373	198	1,549	20,280
Totals	286	30,501	321	2,685	33,793
1987					
106-41&42	0	494	0	661	1,155
106-30	0	209	0	12	221
108	107	497	36	71	710
106-41T	0	17	0	22	39
106-30T	0	3	0	0	3
108T	19	89	6	13	127
Stikine Test	15	439	14	45	513
L.R. Commercial	181	989	59	150	1,380
U.R. Commercial	8	372	10	59	448
Indian Food Fish	47	2,225	57	352	2,681
Tahltan Escape.	90	6,011	119	737	6,958
Catch	377	5,332	182	1,386	7,277
Escapement	90	6,011	119	737	6,958
Totals	468	11,343	302	2,123	14,235

--Continued--

	Age-Specific Catch and Escapement				
Year and Area	1.2	1.3	2.2	2.3	Total
1988					
106-41&42	48	881	0	144	1,073
106-30	0	694	0	51	745
108	33	139	0	50	222
106-41T	2	28	0	5	35
108T	15	22	0	22	59
Stikine Test	125	200	27	55	407
L.R. Commercial	996	608	245	212	2,062
U.R. Commercial	99	172	9	34	313
Indian Food Fish	621	1,073	55	210	1,959
Tahltan Escape.	803	1,389	71	272	2,536
Catch	1,939	3,817	336	784	6,876
Escapement	803	1,389	71	272	2,536
Totals	2,742	5,206	407	1,056	9,412
1989					
106-41&42	0	611	0	346	957
106-30	0	94	0	60	154
108	97	229	0	15	341
106-41T	0	0	0	0	0
108T	30	70	0	5	104
Stikine Test	60	255	30	37	381
L.R. Commercial	550	1,587	433	243	2,813
U.R. Commercial	58	315	27	44	444
Indian Food Fish	276	1,508	127	212	2,124
Tahltan Escape.	1,081	5,904	499	832	8,316
Catch	1,070	4,667	617	963	7,318
Escapement	1,081	5,904	499	832	8,316
Totals	2,151	10,572	1,116	1,795	15,634

[a/] The district test fishery stock and age compositions are estimated to be the same as the commercial catch when no other data are available. The in river test fishery stock and age compositions are estimated to be the same as commercial catch when no other data are data available. The upper river commercial and Indian food fishery catches are assumed to be 90% Tahltan origin with the Tahltan fish having the same age composition as the Tahltan escapement. Assumes all fish captured at Kakwan Point were released alive and accounted for elsewhere (numbers small). In 1983 the age composition of Tahltan sockeye salmon in the District 108 catch is assumed to be the same as in District 106. In 1983 the fraction of the District 108 sockeye catch comprised of Tahltan fish is the average of 1985-1989.

Appendix A.2. Age-specific catch and escapement of non-Tahltan Stikine sockeye salmon, 1983-1989.[a/]

Year and Area	Age-Specific Catch and Escapement							
	0.2	0.3	0.4	1.2	1.3	2.2	2.3	Total
1983								
106	0	0	0	0	308	0	324	632
108	1	26	0	8	72	1	3	111
L.R. Commercial	116	216	0	1,424	6,830	196	383	9,165
U.R. Commercial	1	1	0	10	46	1	3	61
Indian Food Fish	6	11	0	72	346	10	19	465
Mainstem Escape.	370	691	0	4,553	21,841	628	1,223	29,307
Catch	123	254	0	1,514	7,603	208	732	10,434
Escapement	370	691	0	4,553	21,841	628	1,223	29,307
Totals	493	945	0	6,067	29,444	837	1,955	39,741
1984								
106	0	0	0	2,438	983	0	656	4,078
108	4	186	2	60	527	5	24	808
106-41T	0	0	0	36	15	0	10	61
108T	2	73	0	12	239	2	16	345
L.R. Commercial	0	0	0	0	0	0	0	0
U.R. Commercial	0	0	0	0	0	0	0	0
Indian Food Fish	12	50	0	131	293	14	32	533
Mainstem Escape.	828	3,590	0	9,389	20,986	1,013	2,301	38,107
Catch	18	309	2	2,679	2,057	21	738	5,825
Escapement	828	3,590	0	9,389	20,986	1,013	2,301	38,107
Totals	846	3,899	2	12,067	23,044	1,034	3,039	43,932
1985								
106-41&42	0	0	0	0	800	0	962	1,762
106-30	0	0	0	0	744	0	507	1,251
108	2	65		2	14	576	420	683
106-41T	0	0	0	0	20	0	24	44
108T	0	60	5	15	703	5	22	810
Stikine Test	0	0	0	10	764	10	57	842
L.R. Commercial	59	647	2	458	4,798	127	352	6,444
U.R. Commercial	1	11	0	8	81	2	6	108
Indian Food Fish	7	73	0	52	543	14	40	729
Mainstem Escape.	835	9,100	27	6,443	67,471	1,790	4,951	90,617
Catch	69	857	9	557	9,030	162	1,990	12,673
Escapement	835	9,100	27	6,443	67,471	1,790	4,951	90,617
Totals	904	9,957	36	7,000	76,500	1,952	6,941	103,290

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Appendix A.2. (page 2 of 3.)

Year and Area	0.2	0.3	0.4	1.2	1.3	2.2	2.3	Total
	Age-Specific Catch and Escapement							
1986								
106-41&42	0	0	0	82	0	0	419	501
106-30	0	0	0	70	0	0	35	105
108	17	264	0	147	2,357	0	73	2,858
106-41T	0	0	0	2	2	0	5	9
106-30T	0	0	0	0	0	0	0	0
108T	1	11	0	8	149	5	16	190
Stikine Test	2	5	0	38	209	6	6	267
L.R. Commercial	103	256	0	1,303	4,148	271	262	6,342
U.R. Commercial	1	2	0	12	64	2	2	82
Indian Food Fish	3	8	0	60	329	10	10	421
Mainstem Escape.	244	611	0	4,398	24,190	733	733	30,910
Catch	127	546	0	1,722	7,258	294	827	10,774
Escapement	244	611	0	4,398	24,190	733	733	30,910
Totals	371	1,157	0	6,120	31,449	1,027	1,561	41,684
1987								
106-41&42	0	0	0	0	258	0	0	258
106-30	0	0	0	0	710	0	710	
108	0	360	0	49	229	16	53	708
106-41T	0	0	0	0	9	0	0	9
106-30T	0	0	0	0	11	0	0	11
108T	0	56	0	7	52	0	12	127
Stikine Test	8	168	2	132	784	14	105	1,213
L.R. Commercial	96	533	0	899	2,843	99	288	4,758
U.R. Commercial	0	7	0	5	32	1	4	50
Indian Food Fish	2	41	1	32	193	3	26	298
Mainstem Escape.	161	3,583	46	2,825	16,767	299	2,251	25,932
Catch	106	1,165	3	1,125	5,122	133	488	8,141
Escapement	161	3,583	46	2,825	16,767	299	2,251	25,932
Totals	266	4,748	49	3,950	21,889	432	2,739	34,073

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Appendix A.2. (page 3 of 3.)

	Age-Specific Catch and Escapement							
Year and Area	0.2	0.3	0.4	1.2	1.3	2.2	2.3	Total
1988								
106-41&42	0	0	0	0	64	0	0	64
106-30	0	0	0	0	0	0	0	0
108	9	120	6	147	428	0	0	711
106-41T	0	0	0	0	0	0	0	0
108T	8	56	0	11	203	0	0	277
Stikine Test	18	92	0	177	561	27	20	895
L.R. Commercial	364	849	6	2,728	6,061	406	290	10,704
U.R. Commercial	1	4	0	7	22	1	1	35
Indian Food Fish	4	22	0	43	136	6	5	218
Mainstem Escape.	463	2,344	0	4,525	14,310	681	518	22,841
Catch	404	1,142	12	3,114	7,475	440	316	12,904
Escapement	463	2,344	0	4,525	14,310	681	518	22,841
Totals	867	3,486	12	7,639	21,784	1,122	834	35,745
1989								
106-41&42	0	0	0	366	2,949	0	515	3830
106-30	0	0	0	932	54	0	244	1231
108	27	2,292	0	193	5,341	0	164	8017
106-41T	0	0	0	2	13	0	2	17
108T	2	196	0	16	456	0	14	684
Stikine Test	0	236	0	29	887	16	57	1,226
L.R. Commercial	0	2,654	0	305	10,742	246	419	14,366
U.R. Commercial	0	10	0	1	36	1	2	49
Indian Food Fish	0	46	0	6	171	3	11	236
Mainstem Escape.	194	8,647	0	1,459	35,565	711	1,977	48,552
Catch	29	5,433	0	1,850	20,649	266	1,429	29,656
Escapement	194	8,647	0	1,459	35,565	711	1,977	48,552
Totals	223	14,080	0	3,308	56,214	977	3,406	78,208

[a] The district test fisheries stock and age compositions are estimated to be the same as the commercial catch when no other data are available. The in river test fishery stock and age compositions are estimated to be the same as the commercial catch when no other data are available. The upper river commercial and Indian food fishery catches are assumed to be 10% non-Tahltan origin with the non-Tahltan fish having the same age composition as non-Tahltan portion of the test fishery catches. Assumes all fish captured at Kakwan Point were released alive and accounted for elsewhere (numbers small). The 1983 age-composition of non-Tahltan sockeye salmon in the District 108 catch is assumed to be the same as in District 106. In 1983 the fraction of the District 108 sockeye catch comprised of Tahltan fish is the average of 1985-1989.

Appendix A.3. Age-specific catch and escapement of Stikine River sockeye salmon, 1983-1989.[a/]

Year and Area	Age-Specific Catch and Escapement							
	0.2	0.3	0.4	1.2	1.3	2.2	2.3	Total
1983								
106	0	0	0	147	4,902	0	613	5,662
108	1	26	0	14	108	1	7	156
L.R. Commercial	116	216	0	2,144	12,195	231	955	15,857
U.R. Commercial	1	1	0	22	550	2	38	614
Indian Food Fish	6	11	0	164	4,164	16	288	4,649
Escapement	370	691	0	5,020	41,236	657	2,588	50,563
Catch	123	254	0	2,491	21,918	250	1,901	26,938
Escapement	370	691	0	5,020	41,236	657	2,588	50,563
Totals	493	945	0	7,511	63,154	907	4,490	77,501
1984								
106	0	0	0	3,523	2,502	0	727	6,751
108	4	186	2	99	781	8	50	1,131
106-41T	0	0	0	53	37	0	11	101
108T	2	73	0	36	353	5	36	506
L.R. Commercial	0	0	0	0	0	0	0	0
U.R. Commercial	0	0	0	0	0	0	0	0
Indian Food Fish	12	50	0	1,730	3,201	70	265	5,327
Escapement	828	3,590	0	20,316	40,865	1,394	3,891	70,884
Catch	18	309	2	5,441	6,874	83	1,089	13,816
Escapement	828	3,590	0	20,316	40,865	1,394	3,891	70,884
Totals	846	3,899	2	25,757	47,739	1,477	4,979	84,700
1985								
106-41&42	0	0	0	345	19,026	0	1,192	20,563
106-30	0	0	0	12	5,915	0	568	6,495
108	2	65	2	21	868	6	29	993
106-41T	0	0	0	9	480	0	30	519
108T	0	60		5	23	1,048	34	1,177
Stikine Test	0	0	0	33	1,228	15	71	1,347
L.R. Commercial	59	647	2	939	14,567	235	643	17,093
U.R. Commercial	1	11	0	31	1,012	5	25	1,084
Indian Food Fish	7	73	0	205	6,801	33	168	7,287
Escapement	835	9,100	27	8,017	131,719	1,983	6,262	157,943
Catch	69	857	9	1,617	50,946	300	2,760	56,558
Escapement	835	9,100	27	8,017	131,719	1,983	6,262	157,943
Totals	904	9,957	36	9,634	182,664	2,283	9,022	214,501

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Appendix A.3. (page 2 of 3.)

Year and Area	0.2	0.3	0.4	1.2	1.3	2.2	2.3	Total
	Age-Specific Catch and Escapement							
1986								
106-41&42	0	0	0	82	1,740	0	749	2,571
106-30	0	0	0	70	0	0	46	116
108	17	264	0	147	2,750	0	73	3,251
106-41T	0	0	0	2	8	0	7	17
106-30T	0	0	0	0	0	0	0	0
108T	1	11	0	20	379	12	41	464
Stikine Test	2	5	0	41	360	9	16	434
L.R. Commercial	103	256	0	1,378	9,661	340	674	12,411
U.R. Commercial	1	2	0	17	728	9	58	815
Indian Food Fish	3	8	0	90	3,760	47	299	4,208
Escapement	244	611	0	4,558	42,563	931	2,282	51,190
Catch	127	546	0	1,848	19,386	417	1,963	24,287
Escapement	244	611	0	4,558	42,563	931	2,282	51,190
Totals	371	1,157	0	6,406	61,950	1,348	4,245	75,477
1987								
106-41&42	0	0	0	0	752	0	661	1,413
106-30	0	0	0	0	919	0	12	931
108	0	360	0	156	726	52	124	1,418
106-41T	0	0	0	0	26	0	22	48
106-30T	0	0	0	0	14	0	0	14
108T	0	56	0	26	141	6	25	254
Stikine Test	8	168	2	147	1,223	28	151	1,726
L.R. Commercial	96	533	0	1,080	3,832	158	438	6,138
U.R. Commercial	0	7	0	13	404	10	63	498
Indian Food Fish	2	41	1	80	2,417	61	377	2,979
Escapement	161	3,583	46	2,916	22,779	418	2,988	32,890
Catch	106	1,165	3	1,502	10,454	315	1,874	15,419
Escapement	161	3,583	46	2,916	22,779	418	2,988	32,890
Totals	266	4,748	49	4,418	33,232	734	4,862	48,309

--Continued--

Year and Area	Age-Specific Catch and Escapement 0.2	0.3	0.4	1.2	1.3	2.2	2.3	Total
1988								
106-41&42	0	0	0	48	945	0	144	1,137
106-30	0	0	0	0	694	0	51	745
108	9	120	6	180	567	0	50	933
106-41T	0	0	0	2	28	0	5	35
108T	8	56	0	26	225	0	22	336
Stikine Test	18	92	0	302	761	54	75	1,302
L.R. Commercial	364	849	6	3,725	6,669	651	502	12,766
U.R. Commercial	1	4	0	106	193	10	34	348
Indian Food Fish	4	22	0	664	1,210	62	215	2,177
Escapement	463	2,344	0	5,328	15,699	753	790	25,377
Catch	404	1,142	12	5,053	11,292	777	1,099	19,779
Escapement	463	2,344	0	5,328	15,699	753	790	25,377
Totals	867	3,486		12	10,381	26,990	[illegible]	45,156
1989								
106-41&42	0	0	0	366	3,559	0	862	4,787
106-30	0	0	0	932	148	0	305	1,385
108	27	2,292	0	290	5,570	0	179	8,358
106-41T	0	0	0	2	13	0	2	17
108T	2	196	0	46	526	0	19	788
Stikine Test	0	236	0	89	1,142	46	94	1,607
L.R. Commercial	0	2,654	0	855	12,329	679	662	17,179
U.R. Commercial	0	10	0	59	351	27	47	493
Indian Food Fish	0	46	0	282	1,679	131	223	2,360
Escapement	194	8,647	0	2,540	41,469	1,210	2,808	56,868
Catch	29	5,433	0	2,920	25,317	883	2,392	36,974
Escapement	194	8,647	0	2,540	41,469	1,210	2,808	56,868
Totals	223	14,080	0	5,460	66,786	2,093	5,201	93,842

[a] The district test fishery stock and age compositions are estimated to be same as the commercial catch when no other data are available. The in river test fishery stock and age compositions are estimated to be the same as the commercial catch when no other data are available. The age compositions of the upper river commercial and Indian food fishery catches are assumed to be the same as the Tahltan escapement for Tahltan fish and as the lower river test or commercial catches for the non-Tahltan fish. Assumes all fish captured at Kakwan Point were released alive and accounted for elsewhere (numbers small). In 1983 the age composition of Stikine sockeye salmon in the District 108 catch is assumed to be the same as in District 106. In 1983 the fraction of the District 108 sockeye catch comprised of Stikine fish is the average of 1985-1989.

Appendix A.4. Brood tables for Tahltan, non-Tahltan, and all Stikine sockeye salmon.

Spawners		Recruits							
Year	Number	0.2	0.3	0.4	1.2	1.3	2.2	2.3	Total
Tahltan									
1978	22,788					33,710	71	1,940	35,720
1979	10,211				1,445	24,695	443	2,081	28,664
1980	11,018				13,690	106,164	332	2,685	122,870
1981	50,790				2,634	30,501	321	2,123	35,579
1982	28,257				286	11,343	302	1,056	12,987
1983	21,256				468	5,206	407	1,795	7,876
1984	32,777				2,742	10,572	1,116		14,430
1985	67,326				2,151				2,151
1986	20,280								
Non-Tahltan									
1978[a]	22,788			0		29,444	837	3,039	33,320
1979	16,608		945	2	6,067	23,044	1,034	6,941	38,032
1980	30,806	493	3,899	36	12,067	76,500	1,952	1,561	96,508
1981	61,615	846	9,957	0	7,000	31,449	1,027	2,739	53,018
1982	19,964	904	1,157	49	6,120	21,889	432	834	31,385
1983	29,307	371	4,748	12	3,950	21,784	1,122	3,406	35,393
1984	38,107	266	3,486	0	7,639	56,214	977		68,583
1985	90,617	867	14,080		3,308				18,256
1986	30,910	223							223
Stikine									
1978[a]	45,576			0		63,154	907	4,979	69,041
1979	26,819		945	2	7,511	47,739	1,477	9,022	66,696
1980	41,824	493	3,899	36	25,757	182,664	2,283	4,245	219,378
1981	112,405	846	9,957	0	9,634	61,950	1,348	4,862	88,597
1982	48,221	904	1,157	49	6,406	33,232	734	1,889	44,371
1983	50,563	371	4,748	12	4,418	26,990	1,529	5,201	43,269
1984	70,884	266	3,486	0	10,381	66,786	2,093		83,013
1985	157,943	867	14,080		5,460				20,407
1986	51,190	223							223

[a] The non-Tahltan escapement was assumed to be the same as the Tahltan escapement.

Appendix A.5. Smolt-recruit relationship for Tahltan sockeye salmon.

Smolt		Recruits					
Year	Number	1.2	1.3	2.2	2.3	Total	Survival Rate
1984	219702	286	11,343	321	2,123	14,073	0.0641
1985	613531	468	5,206	302	1,056	7,031	0.0115
1986	244330	2,742	10,572	407	1,795	15,516	0.0635
1987	810432	2,151		1,116		3,267	0.0040
1988	1170136						
1989	580574						

Average survival 0.046339
Average Marine Age 2 = 0.118515 3 = 0.881484
Forecast for 1990 3 ocean 33,105 2 ocean 6,426 Total 39,531

Appendix B.1. Regressions for sibling forecasts of Tahltan sockeye salmon.

X in Year t Y in Year t+1	1.2 1.3	1.2 All
All Years		
Constant	5,675	12,099
Std Err of Y Est	9,483	12,655
R Squared	0.950	0.912
No. of Observations	6	6
Degrees of Freedom	4	4
X Coefficient(s)	7.262	7.169
Std Err of Coef.	0.835	1.115
All years except 1983(X)-1984(Y)		
Constant	3,281	6,957
Std Err of Y Est	9,464	8,585
R Squared	0.962	0.970
No. of Observations	5	5
Degrees of Freedom	3	3
X Coefficient(s)	7.436	7.543
Std Err of Coef.	0.851	0.772
All years except 1984(X)-1985(Y)		
Constant	9,134	15,211
Std Err of Y Est	10,436	14,306
R Squared	0.278	0.179
No. of Observations	5	5
Degrees of Freedom	3	3
X Coefficient(s)	4.838	4.988
Std Err of Coef.	4.503	6.172
All years except 1985(X)-1986(Y)		
Constant	4,355	11,448
Std Err of Y Est	10,336	14,504
R Squared	0.955	0.913
No. of Observations	5	5
Degrees of Freedom	3	3
X Coefficient(s)	7.311	7.193
Std Err of Coef.	0.914	1.282
All years except 1986(X)-1987(Y)		
Constant	4,449	12,069
Std Err of Y Est	10,685	14,613
R Squared	0.949	0.903
No. of Observations	5	5
Degrees of Freedom	3	3
X Coefficient(s)	7.383	7.172
Std Err of Coef.	0.991	1.356

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Appendix B.1. * (page 2 of 2.)

	X in Year t Y in Year t+1	1.2 1.3	1.2 All
All years except 1987(X)-1988(Y)			
Constant		6,953	14,096
Std Err of Y Est		10,647	14,055
R Squared		0.946	0.906
No. of Observations		5	5
Degrees of Freedom		3	3
X Coefficient(s)		7.141	6.980
Std Err of Coef.		0.982	1.296
All years except 1988(X)-1989(Y)			
Constant		9,097	15,773
Std Err of Y Est		5,397	10,435
R Squared		0.987	0.951
No. of Observations		5	5
Degrees of Freedom		3	3
X Coefficient(s)		7.149	7.048
Std Err of Coef.		0.477	0.922

Appendix B.2. Regressions for sibling forecasts of non-Tahltan sockeye salmon.

X in Year t Y in Year t+1	1.2 1.3	1.2 All	1.2 All non 0	0.2 All 0	0.2+1.2 All
All Years					
Constant	(16,438)	(10,776)	(10,551)	2,342	(11,478)
Std Err of Y Est	10,224	13,486	9,903	4,840	13,493
R Squared	0.839	0.817	0.869	0.178	0.817
No. of Observations	6	6	6	6	6
Degrees of Freedom	4	4	4	4	4
X Coefficient(s)	7.691	9.374	8.387	7.162	8.710
Std Err of Coef.	1.683	2.220	1.630	7.688	2.064
All years except 1983(X)-1984(Y)					
Constant	(13,088)	(9,769)	(10,016)	3,427	(11,638)
Std Err of Y Est	10,861	15,511	11,411	3,689	18,473
R Squared	0.847	0.810	0.864	0.035	0.730
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.431	9.295	8.346	2.121	8.856
Std Err of Coef.	1.822	2.602	1.914	6.465	3.109
All years except 1984(X)-1985(Y)					
Constant	(15,867)	(6,514)	(2,802)	2,984	(3,215)
Std Err of Y Est	11,804	15,517	11,183	5,321	15,315
R Squared	0.518	0.446	0.509	0.097	0.461
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.594	8.650	7.072	5.198	7.415
Std Err of Coef.	4.230	5.561	4.007	9.161	4.631
All years except 1985(X)-1986(Y)					
Constant	(15,053)	(7,714)	(8,688)	(796)	(8,815)
Std Err of Y Est	11,190	13,163	10,253	1,839	12,015
R Squared	0.852	0.860	0.891	0.874	0.884
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.664	9.313	8.351	15.243	8.771
Std Err of Coef.	1.842	2.167	1.688	3.342	1.838
All years except 1986(X)-1987(Y)					
Constant	(12,485)	(5,116)	(5,229)	2,288	(5,980)
Std Err of Y Est	10,379	13,328	8,566	5,588	13,863
R Squared	0.858	0.843	0.912	0.151	0.830
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.391	8.944	7.983	7.224	8.298
Std Err of Coef.	1.738	2.232	1.434	9.895	2.170

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Appendix B.2. (page 2 of 2.)

X in Year t Y in Year t+1	1.2 1.3	1.2 All	1.2 All non 0	0.2 All 0	0.2+1.2 All
All years except 1987(X)-1988(Y)					
Constant	(27,463)	(24,124)	(22,922)	2,177	(27,292)
Std Err of Y Est	10,129	13,733	9,189	5,588	13,212
R Squared	0.864	0.837	0.903	0.123	0.849
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	8.907	10.845	9.751	7.367	10.328
Std Err of Coef.	2.038	2.763	1.849	11.355	2.513
All years except 1988(X)-1989(Y)					
Constant	(17,619)	(12,253)	(11,434)	4,155	(12,087)
Std Err of Y Est	7,839	10,986	9,340	3,893	11,997
R Squared	0.917	0.893	0.904	0.028	0.873
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.464	9.090	8.218	2.023	8.380
Std Err of Coef.	1.296	1.816	1.544	6.821	1.849

Appendix B.3. Regressions for sibling forecasts of Stikine sockeye salmon.

X in Year t Y in Year t+1	1.2 1.3	1.2 All	1.2 All non 0	0.2 All 0	0.2+1.2 All
All Years					
Constant	(9,695)	8,236	4,819	2,342	5,389
Std Err of Y Est	3,179	11,166	10,888	4,840	11,659
R Squared	0.998	0.974	0.974	0.178	0.972
No. of Observations	6	6	6	6	6
Degrees of Freedom	4	4	4	4	4
X Coefficient(s)	7.449	7.995	7.677	7.162	7.805
Std Err of Coef.	0.185	0.649	0.633	7.688	0.662
All years except 1983(X)-1984(Y)					
Constant	(10,216)	2,464	(1,326)	4,155	(2,396)
Std Err of Y Est	3,543	7,347	5,554	3,893	10,014
R Squared	0.998	0.992	0.995	0.028	0.984
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.469	8.215	7.911	2.023	8.226
Std Err of Coef.	0.210	0.436	0.330	6.821	0.597
All years except 1984(X)-1985(Y)					
Constant	(6,844)	10,099	10,790	2,984	12,665
Std Err of Y Est	3,495	12,872	12,352	5,321	13,123
R Squared	0.970	0.739	0.707	0.097	0.728
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.064	7.744	6.872	5.198	6.888
Std Err of Coef.	0.722	2.660	2.553	9.161	2.430
All years except 1985(X)-1986(Y)					
Constant	(9,665)	10,650	6,011	(796)	8,240
Std Err of Y Est	3,670	11,302	12,194	1,839	11,040
R Squared	0.998	0.980	0.975	0.874	0.981
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.448	7.954	7.656	15.243	7.769
Std Err of Coef.	0.214	0.658	0.710	3.342	0.628
All years except 1986(X)-1987(Y)					
Constant	(7,701)	12,875	9,295	2,288	9,709
Std Err of Y Est	1,885	10,609	10,397	5,588	11,747
R Squared	0.999	0.980	0.979	0.151	0.976
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.359	7.787	7.476	7.224	7.615
Std Err of Coef.	0.114	0.641	0.628	9.895	0.696

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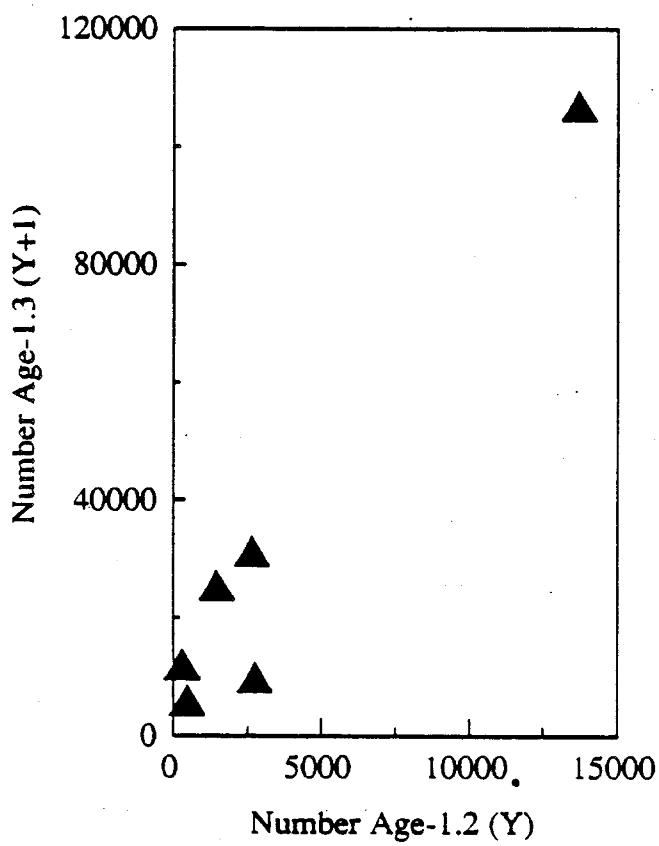
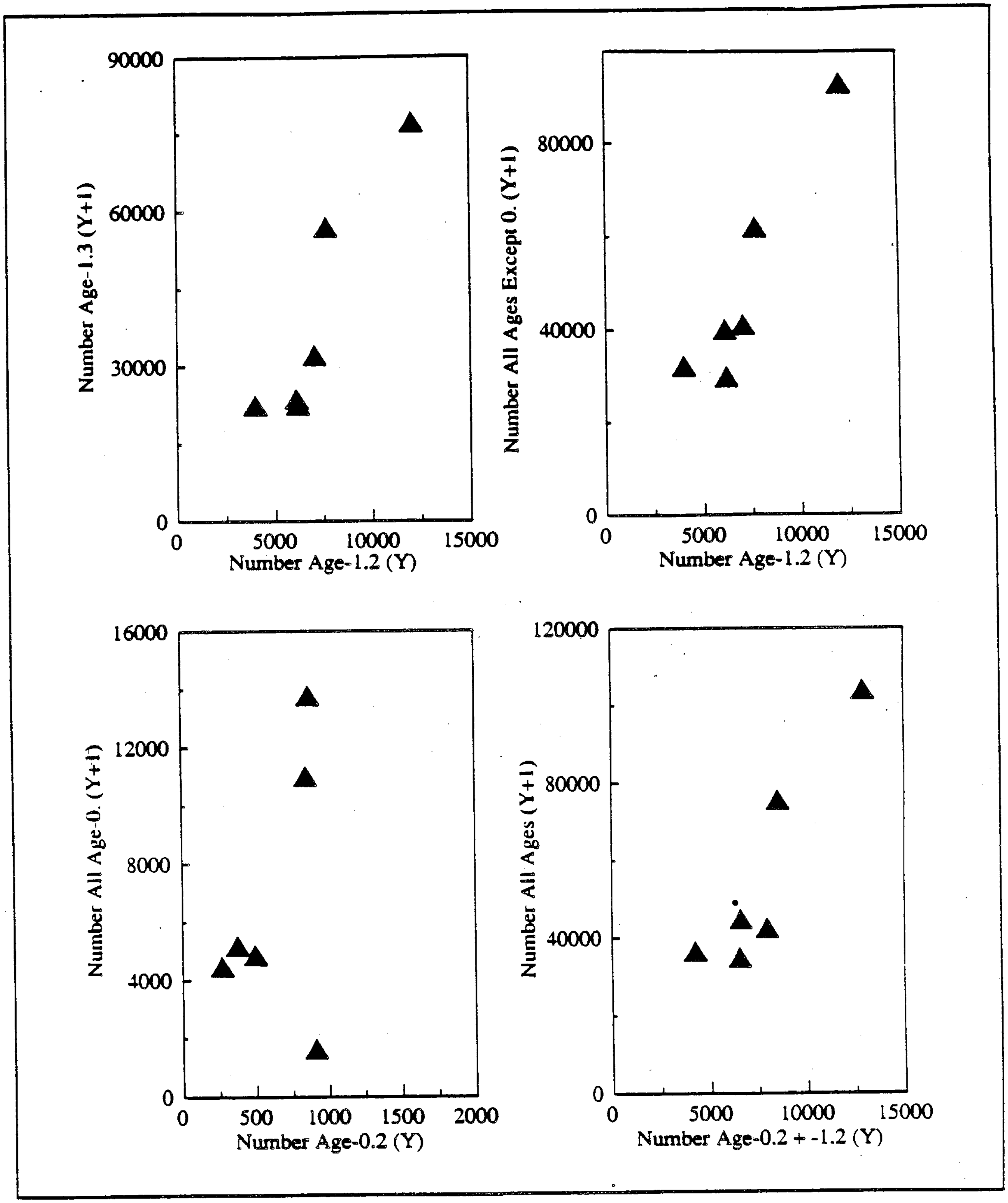
Appendix B.3. (page 2 of 2.)

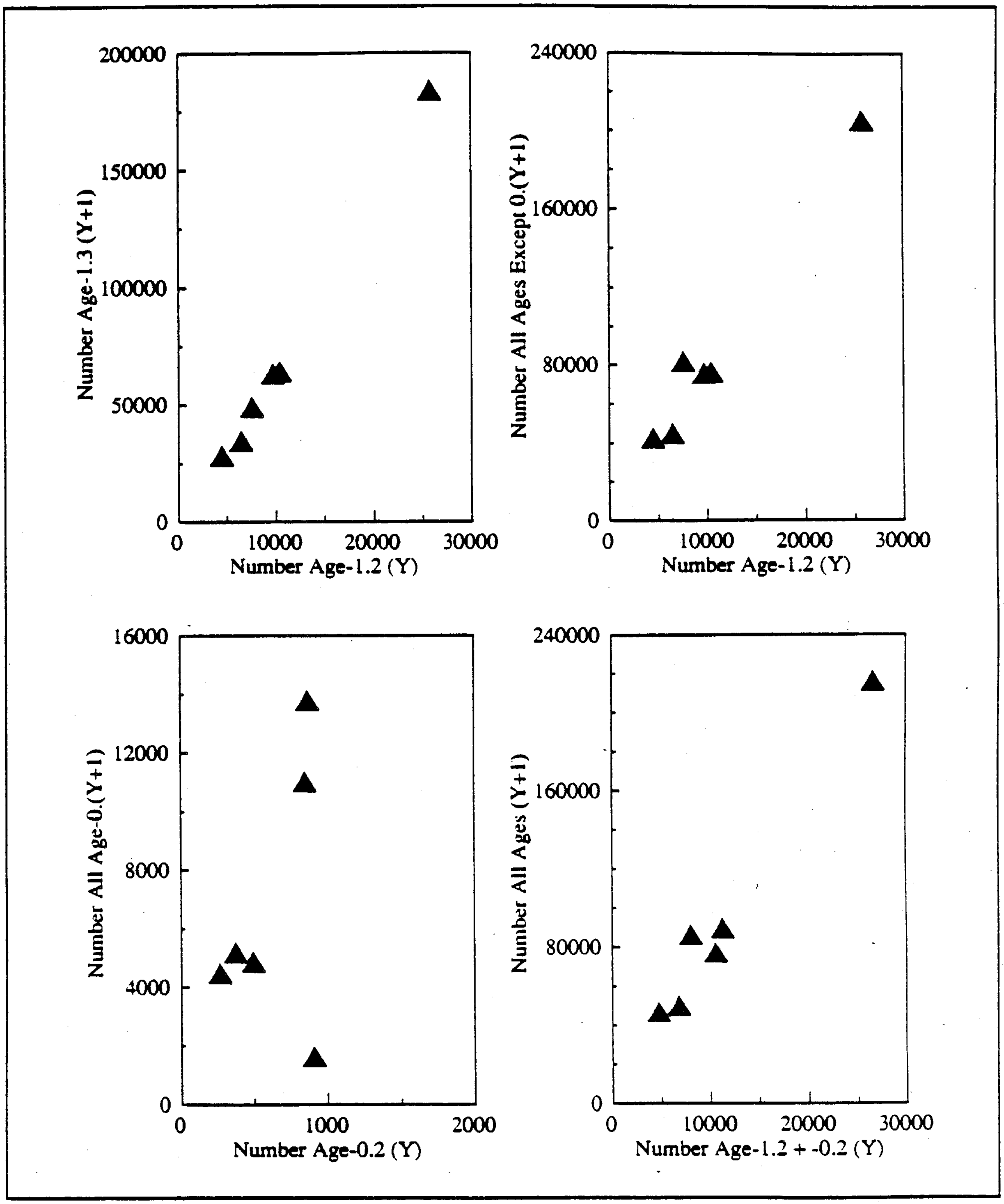
X in Year t Y in Year t+1	1.2 1.3	1.2 All	1.2 All non 0	0.2 All 0	0.2+1.2 All
All years except 1987(X)-1988(Y)					
Constant	(11,814)	7,339	3,666	2,177	3,495
Std Err of Y Est	2,584	12,846	12,492	5,588	13,277
R Squared	0.999	0.970	0.970	0.123	0.968
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.563	8.044	7.739	7.367	7.905
Std Err of Coef.	0.164	0.814	0.792	11.355	0.828
All years except 1988(X)-1989(Y)					
Constant	(9,514)	7,681	5,881	4,155	5,257
Std Err of Y Est	3,631	12,787	12,172	3,893	13,456
R Squared	0.998	0.975	0.975	0.028	0.972
No. of Observations	5	5	5	5	5
Degrees of Freedom	3	3	3	3	3
X Coefficient(s)	7.448	7.999	7.671	2.023	7.806
Std Err of Coef.	0.211	0.743	0.708	6.821	0.764



Appendix C.1. Sibling correlation for Tahltan sockeye salmon. Data from age-1.2 fish in year t and age-1.3 fish in year t+1.



Appendix C.2. Sibling correlation for non-Tahltan sockeye salmon. Data from age-1.2 fish in year t and age-1.3 fish in year t+1 (upper left), age-1.2 fish in year t and all non-age-0. fish in year t+1 (upper right), age-0.2 fish in year t and all age-0. fish in year t+1 (lower left), and age-0.2+ -1.2 fish in year t and all fish in year t+1 (lower right).



Appendix C.3. Sibling correlation for Stikine sockeye salmon. Data from age-1.2 fish in year t and age-1.3 fish in year t+1 (upper left), age-1.2 fish in year t and all non-age-0. fish in year t+1 (upper right), age-0.2 fish in year t and all age-0. fish in year t+1 (lower left), and age-0.2+ -1.2 fish in year t and all fish in year t+1 (lower right).